

# Effects of Bracing System on Multistoried Steel Building

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## ABSTRACT

In recent years, steel construction has shifted from moment-resisting frames to concentric braced frames in regions of highly seismic prone area. Bracing element in structural system by providing more stiffness plays a vital role in structural behaviour to resist earthquake forces. Concentric bracing is one of the most common lateral load resistant systems in building frames due to their manufacturing simplicity and economy. In this work, different types of bracing (X bracing, Inverted V bracing, K bracing, V bracing, Forward bracing, Backward bracing) have been analysed and comparison has been made on the basis of maximum lateral displacement at each floor level due to seismic and wind loading. The main parameters considered to compare the seismic performance of buildings were bending moment, shear force, story drift, storey shear and concluded that the braced building of the storey drift decreases as compared to the unbraced building which indicates that the overall response of the building decreases, the displacement of the building decreases depending upon the different bracing system employed and the bracing sizes.

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## INTRODUCTION

### General

India at present is fast developing country which requires demands in increase of infrastructure facilities along with the growth of population. Due to increased population, the demand and cost of land for housing is increasing day by day. To fulfil the need of the land for housing and other commercial purposes, vertical development that is multi-storey buildings are the only option. This type of development needs safety because these multi-storey buildings are highly susceptible to additional lateral loads due to earthquake and wind. In other countries, as the elevation of building increases, its reaction to lateral loads increases. Multi-storey reinforced concrete buildings are vulnerable to excessive deformation, which necessitate the introduction of special measures to decrease this deformation.

Due to the lateral forces acting on the building storey drift takes place which is more vulnerable as the height of the structure increases. To satisfy strength and serviceability limit, lateral stiffness is a major consideration in the design of tall buildings. The simple parameter that is used to estimate the lateral stiffness of a building is the drift index defined as the ratio of the maximum deflections at the top of the building to the total height. Different structural forms of tall buildings can be used to improve the lateral stiffness and to reduce the drift index. Steel braced frame is one of the lateral loads opposing frameworks in multi-storey structures. Steel bracing system enhances the resistance of the structure against horizontal forces by expanding its stiffness and stability. Bracings hold the structure stable by exchanging the horizontal loads, for example, earthquake or wind burdens down to the ground and oppose sidelong loads, in that way keep the influence of the structure. Steel bracing members in RC multi-storey building is conservative, simple to set up, involve less space and give obliged quality and inflexibility. There are various types of bracing systems like X bracing, V bracing, inverted V bracing, K bracing, diagonal bracing and so on.

### BRACED FRAMES

Braced frames provide resistance to lateral forces acting on a structure. The members of a braced frame act as a truss system and are subjected primarily to axial stress. Depending on the diagonal force, length, required stiffness, and clearances, the diagonal members can be made of double angles, channels, tees, tubes, or even wide flange shapes. Besides performance, the shape of the diagonal is often based on connection considerations. The braces are often placed around

service cores and elevators, where frame diagonals may be enclosed within permanent walls. The braces can also be joined to form a closed or partially closed three-dimensional cell so that torsional loads can be resisted effectively. A height-to-width ratio of 8-10 is considered to form a reasonably effective bracing system.

## LITERATURE REVIEW

### Back Ground

Considerable research has been conducted on the behavior of steel bracing elements and on connections and sub assemblages from concentrically braced steel-frame structures under loading representative of strong earthquake ground shaking. Because of the rapid evolution of codes, much of this research is not necessarily consistent with modern construction detailing; however, many of fundamental observations from these investigations are germane to an assessment of modern design and analysis procedure. Moreover, experimental data are critical to the validation and calibration of analytical models used for carrying out simulations to predict the performance of braced-frame structures. The available body of literature extends over several decades and is rapidly growing. As such, it cannot be adequately summarized in a brief chapter. Instead, an overview of major references is provided here along with useful citations to previous works that contain detailed reviews of related literature.

This section is a brief summary of past work carried on braced frames, specifically concentric braced frames. In this section, analytical studies focusing on steel braces and steel retrofit of existing structures surveyed within the scope of this thesis will be briefly summarized.

**Badoux and Jirsa (1990)** investigated the behavior of braced frames both analytically and experimentally. Retrofitted frame was prepared to have deep beams and short columns and tested under lateral cyclic loading. An analytical study was conducted by simulating an interior column in a braced frame loaded laterally. In addition to that, a parametric study was conducted to understand the effect of slenderness ratio of braces on the response of retrofitted frame. Their studies showed that-

- Steel frame and the bracing system could be taken as independent systems and designer strength and stiffness by changing brace sections.
- To have acceptable seismic behaviour, brace sections should be designed to remain elastic because of the unpredictable nature of exposed seismic loading that can trigger buckling.
- Reducing slenderness ratio would help to prevent inelastic buckling effects on the brace sections.

**Hines and Jacob (1996)** discussed related to the seismic performance of low ductility steel system for moderate seismic regions. Performance assessment results of eccentric braced frame on the basis of storey drift capacity, response to higher mode effects and frame overturning forces were presented. Their results show that there is no improvement in storey drift on a low ductility CBF in moderate region. Section at the top of the building experienced excessive drift due to higher mode effects, but at the same time higher mode effects benefit column design criteria by reducing building overturning forces. It is therefore advisable to study the relationship between frame ductility and column over strength demand with the aim of minimizing lateral drift.

**Nandi and Hiremath (2015)** presented seismic performance of non-ductile buildings with eccentric steel bracing of inverted Y type was investigated. 10, 15 and 20 storey buildings were analysed by using pushover analysis. The analysis was carried out by using software SAP2000v17.

## METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge.

### Load Considered

#### Dead loads

A load fixed in magnitude and in position is called a dead load. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights.

For floors; unit weight of reinforces cement concrete= 25 kN/m<sup>3</sup> Unit weight of steel is = 78.5 kN/m<sup>3</sup>

### Design Of Wind Pressure

The design wind pressure at any height above ground level shall be calculated by the following relationship between wind pressure and wind speed: -

$$PZ = 0.6 V_z^2$$

Where  $PZ$  is design wind pressure in  $N/m^2$  at height  $z$  and  $V_z$  is design wind velocity in  $m/s$  at height  $z$ ,

### Analysis Of Models

#### GENERAL

The building used for this study was designed to the standards presented by the IS 800: 2007 and IS 1893 (Part 1): 2002. A multi-storey steel building is analysed in STAAD Pro.

The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, wind loads and other external loads, the structure would be required to bear.

### STEEL FRAMES

The frame used for this study is a 20 (G+19) storey, steel braced structures. The typical floor height is 3 m with a total 60 m of the building. In plan, the sides span 20 meter by 20 meter divided into 5 meter square bays as shown in figure 4.1

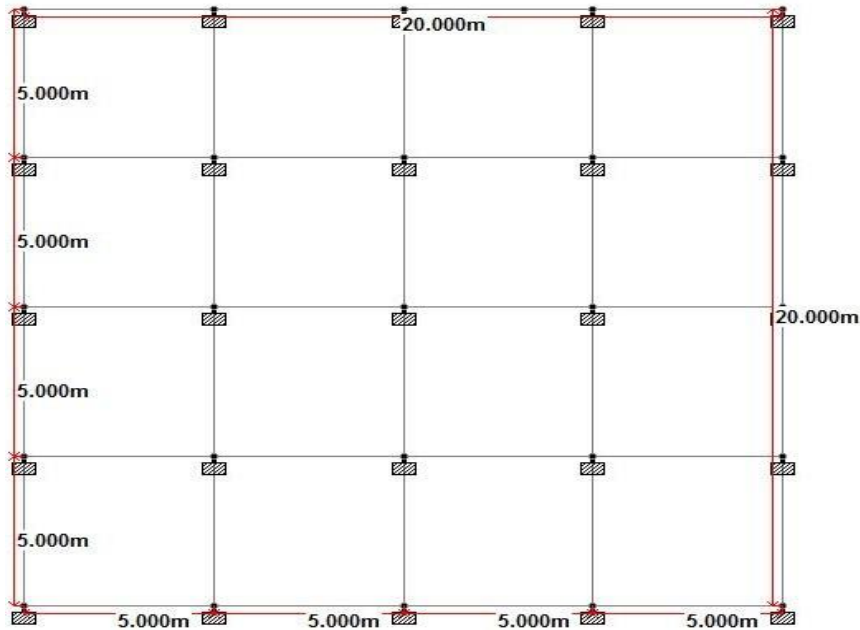


Fig. 4.1 Structural Floor Plan Of Steel Concentric Frame

## RESULTS AND DISCUSSIONS

### Story Displacement

Storey lateral displacement at each floor level in X-direction is presented in the table from 5.1 to 5.5

Table 5.1 Storey displacement in X & Z-direction without bracing at different levels

Storey	Displacement X	Displacement Z
0	0	0
1	0.1163	0.1163
2	0.3029	0.3029
3	0.5128	0.5128

4	0.7333	0.7333
5	0.9572	0.9572
6	1.1796	1.1796
7	1.398	1.398
8	1.6108	1.6108
9	1.8167	1.8167
10	2.015	2.015
11	2.2045	2.2045
12	2.384	2.384
13	2.553	2.553
14	2.711	2.711
15	2.8575	2.8575
16	2.9923	2.9923
17	3.1149	3.1149
18	3.224	3.224
19	3.3197	3.3197
20	3.4036	3.4036

## CONCLUSIONS

### GENERAL

This paper has presented a general review of structural systems for tall buildings. Unlike the height-based classifications in the past, a system-based broad classification has been proposed. Various structural systems within each category of the new classification have been described with emphasis on innovations.

Whenever a structure is provided with Bracings though it may be concentric or eccentric then it gives more resistance to lateral deflection and also it is suitable in earthquake prone areas. The performance of the building has been evaluated in terms of lateral storey displacement, storey drift as well as axial force and bending moment in columns at different storey level. Improvement can be achieved by redesigning the brace and floor beams to a weak brace and strong beam system, as in Special CBFs. EBFs provide a unique combination of stiffness, strength and ductility, making them a viable lateral load resisting system for steel structures subject to earthquake loads.

On the basis of present study the following conclusions can be drawn:

- Out of all the bracing systems, inverted Backward bracing system is giving maximum shear force.
- Forward bracing system is producing maximum bending moment in comparison to the other bracings.
- Most suitable bracing system is backward bracing system.
- Lateral displacement at the top floor is reduced approximately 50% for Backward braced in frame structure compared to without bracing system.

### SCOPE OF FUTURE STUDY

Braces are likely to develop significant bending moments and shear forces in actual applications and the effect of this on behaviour of braced frame is unclear. An analytical study can be made to simulate this behaviour.

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